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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME OF THE

MICHIGAN MEETING

AT

DETROIT

AND

ANN ARBOR

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FEBRUARY 6, 1942 Vol. 17, No. 1

BULLETIN

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AMERICAN PHYSICAL SOCIETY

MICHIGAN MEETING, DETROIT–ANN ARBOR

February 20–21, 1942

THE 247th regular meeting of the American Physical Society will be held in Detroit, Michigan, on Friday, February 20 and in Ann Arbor, Michigan, on Saturday, February 21, 1942. The Ohio Section of the Society will join in this occasion, which accordingly is also to be designated as their midwinter meeting of the season 1941–42. The sessions in Detroit will be held at the Rackham Educational Memorial, those at Ann Arbor in the Rackham Building of the University of Michigan.

Hotel. The hotel recommended at Detroit is the Book-Cadillac, which offers rooms at $3 per day single and $5 double. Reservations should be made as early as possible, by letter to the hotel. Members are reminded that it is the practice of hotels not to hold reservations into the evening hours, unless specifically so requested (with an indication of the presumptive hour of arrival of the guest). Members and guests of the Society will be conveyed from the hotel to Ann Arbor and back in chartered busses.

The **Rackham Educational Memorial,** which is newly inaugurated and of which ours is one of the first conventions to enjoy the hospitality, is located at a distance of some miles from the Book-Cadillac and other leading hotels. It may be reached by taking any northbound car or bus marked "Woodward" excepting busses marked "Express." In returning to the hotel, leave the car or bus at Michigan Avenue.

A **symposium on various topics of applied physics** will be held in the Small Lecture Room of the Rackham Memorial (Detroit) on Friday afternoon, commencing at 1:45 P.M. The speakers and the titles of their papers are the following:

Ceramic Insulators for Spark Plugs. FRANK RIDDLE, *Ceramic Division, Champion Spark Plug Co., Detroit.*

The Fatigue Characteristics of Rubber. F. F. YOST, *U. S. Rubber Co., Detroit.*

Static Electric Effects on Rubber Tired Vehicles. NIEL HANDEL, *U. S. Rubber Co., Detroit.*

Some Applications of X-Ray Inspection to Defense Problems. DON M. MCCUTCHEON, *Metallurgical Engineer, Ford Motor Co., Dearborn.*

A **symposium on the infra-red** will be held in the amphitheatre of the Rackham Building (Ann Arbor) on Saturday afternoon, commencing at 1:45 P.M. The speakers and the titles of their papers include the following:

Precision Measurements with the Infra-Red Recording Prism Spectrometer. H. M. RANDALL, *University of Michigan.*

The Application of a Lithium Fluoride Prism in Infra-Red Spectroscopy. NORMAN WRIGHT, *The Dow Chemical Company, Midland.*

Coriolis Interaction and the Infra-Red Spectra of Certain Polyatomic Molecules. HARALD H. NIELSEN, *Ohio State University.*

It is anticipated that one or two additional papers will be arranged.

The **Council** will meet at 4:15 P.M. on Friday in the Rackham Memorial, in a room later to be designated.

The **dinner** will be held on Friday evening at seven o'clock. The place has not yet been definitely chosen, but will be specified on a supple-

mentary announcement which is to be distributed at the Book-Cadillac Hotel. The price will be between $1.75 and $2.25. As caterers like to have some idea of how many diners are to be expected at an organized dinner, it will be a great favor if members willing to promise in advance to come to the dinner will send a postcard or a letter to Dr. G. P. Brewington, Lawrence Institute of Technology, Detroit, Michigan. The supplementary announcement will also contain information about the after-dinner speakers, about the ladies' programme planned by the Local Committee for Friday, and about employment opportunities for physicists in the automotive industries and elsewhere.

GENERAL RULES RELATING TO PAPERS

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Some of them were presumably evoked by the summons of the Secretary of the Ohio Section, but no attempt is made to distinguish these. Proofs of the abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Other meetings are planned as follows:

248. April 30, May 1 and 2, 1942. Baltimore.
249. June 25–27, 1942. State College, Pennsylvania.
250. July 11, 1942. Pacific Coast Meeting. Berkeley.

Sectional Meeting. The Secretary of the Southeastern Section of the Physical Society notifies us that its annual meeting is to be held on April 10–11, 1942 in Oxford, Mississippi at the University of Mississippi.

KARL K. DARROW, *Secretary*
Columbia University, New York, New York.

February 6, 1942.

CALENDAR

Friday morning, February 20—Rackham Memorial (Detroit)

10:00 o'clock: Room 3: Session A. Papers 1–9. See pages 5–6.

10:00 o'clock: Room 7: Session B. Papers 10–18. See pages 7–8.

Friday afternoon, February 20—Rackham Memorial (Detroit)

1:45 o'clock: Small Lecture Room: Symposium on various topics of applied physics. Speakers: Frank Riddle, F. F. Yost, Niel Handel, and Don M. McCutcheon. See page 8.

4:15 o'clock: Meeting of the Council: Room to be announced.

Friday evening, February 20

7:00 o'clock: Dinner: Place to be announced.

Saturday morning, February 21—Rackham Building (Ann Arbor)

10:00 o'clock: Amphitheatre: Session C. Papers 19–27. See pages 9–11. To be read by title: Paper 28. See page 11.

Saturday afternoon, February 21—Rackham Building (Ann Arbor)

1:45 o'clock: Amphitheatre: Symposium on the infra-red. Speakers: H. M. Randall, Norman Wright, Harald H. Nielsen, and others. See page 11.

PROGRAMME

FRIDAY MORNING AT 10:00 O'CLOCK

Rackham Memorial (Detroit)—Room 3

Session A

1. Rubber in Vibration. S. D. GEHMAN, *The Goodyear Tire & Rubber Co.*—A machine is described which has been used for determining the vibration properties of various types of rubber mountings used for the isolation of mechanical vibrations. The vibrations are excited by oppositely rotating eccentric weights and are recorded on a tape. It was found that resonance curves for various types of rubber vibrations such as shear, torsion, and compression are, except for some minor deviations, adequately accounted for by the equation which contains a damping term proportional to the velocity and inversely proportional to the frequency. The apparent static modulus of rubber in compression depends upon the shape of the piece, more explicitly, on the ratio of load area to the free area. The same is true for the dynamic modulus. It was found that pieces of similar shape have identical values for the dynamic modulus and also for the internal friction. Some curves are given showing the dependence of dynamic modulus and internal friction on the shape factor. The dynamic stiffness shows the largest deviation from the static values at high shape factors. The internal friction has a linear relationship to the dynamic modulus when the shape factor is varied. This results in damping which is practically independent of the shape.

2. Equations of State for Stressed Rubber. R. H. CASTON, R. L. ANTHONY AND E. GUTH, *University of Notre Dame.*—A simple technique was developed to obtain the equations of state of typical unaccelerated and accelerated pure gum compounds which do not show crystallization in the range of extensions investigated. The samples were relaxed at constant length until the change in force with time was negligibly small. This technique yielded for both types of compounds: (1) Linear dependency of stress upon absolute temperature, (2) S-shaped stress-strain curves, (3) a thermoelastic inversion point. This inversion point occurs at 10 percent extension for the unaccelerated compound and at 15 percent for the accelerated compound. Below these critical extensions the stress decreases with rising temperature as in the case of a normal solid; above these critical extensions the stress increases with rising temperature. Using thermodynamics only, the stress-strain curves were decomposed into their additive parts due to internal energy and entropy, the entropy stress being S-shaped. The decomposed parts were compared with the theory of James and Guth.[1] This theory explains that the thermoelastic inversion point is due to ordinary thermal expansion, accounts quantitatively for the dependency of the entropy stress on extension and for the linearity of the stress-temperature curves.

[1] H. M. James and E. Guth, Phys. Rev. **59**, 111 (1941); E. Guth and H. M. James, Ind. Eng. Chem. **33**, 624 (1941).

3. The Transition from Thermionic to Cold Emission. CHARLES J. MULLIN, *Saint Louis University*, AND EUGENE GUTH, *University of Notre Dame.*—The theory of Schottky emission is extended to include in the current those electrons which tunnel through the top of the potential barrier at the metal surface when rather strong electric fields are used. It is found that these tunnelling electrons contribute to the periodic deviations from the Schottky line, increasing the amplitude of the deviations; this increase leads to a better agreement with experiment, especially for large fields. This agreement requires that the Nottingham[1] reflection coefficient be very small for fields greater than 10^4 volts per cm. Expressions are developed for the electron current emitted by a metal for various field intensities ranging from the small fields of thermionic work to the large fields used in cold emission. Results are obtained to indicate the temperature and field dependence of the electron current for all fields and temperatures of interest. Of particular interest is the expression developed for the current in the "transition region," i.e., $T \sim 500$–$1200°K$ and $F \sim 10^7$–10^8 volts per cm. The modifications which must be made in the theory to take account of the polycrystalline nature of the emitting surface have no effect on the periodic deviations from the Schottky line, and very little effect on the fluctuations observed in field photo-currents.

[1] W. B. Nottingham, Phys. Rev. **49**, 78 (1936).

4. Electronic Energy Bands in Face-Centered Iron. J. B. GREENE, *University of Illinois*, AND MILLARD F. MANNING, *University of Pittsburgh.*—Energy bands for the face-centered form of metallic iron have been calculated, by using relations given previously by Krutter[1] and by Shockley.[2] E *vs.* k curves for a number of directions in k space have been calculated. From these, energy contours in k space have been drawn and the number of energy levels per unit energy range obtained. In general, the energy bands resemble those obtained for copper by Krutter, but the concentration of energy levels near the top of the "d" band is less than Slater[3] obtained for

copper. From the $n(E)$ curves interpretations of a number of properties of gamma-iron can be given.

[1] H. M. Krutter, Phys. Rev. **48**, 664 (1935).
[2] W. Shockley, Phys. Rev. **51**, 128 (1936).
[3] J. C. Slater, Phys. Rev. **49**, 537 (1936).

5. Electronic Energy Band in Body-Centered Iron. MILLARD F. MANNING, *University of Pittsburgh.*—Energy bands for the body-centered form of iron have been calculated by the Wigner-Seitz-Slater method by using relations given previously by Chodorow and Manning.[1] The structure of the energy bands is different from that obtained for metallic tungsten, which is the only other body-centered transition metal for which calculations have been made. There is one narrow band which begins at the energy for which $3s_1'g_2'+2s_2'g_1'=0$, three bands beginning at the energy for which $d_1'=0$, and two beginning at the energy for which $d_2'=0$. The band which begins at $3s_1'g_2'+2s_2'g_1'=0$ accounts for most of the binding energy and is probably related to the 2.56 electrons per atom which Pauling has suggested form homopolar bonds in iron group elements.

The $n(E)$ curves for the body-centered structure show interesting differences from the $n(E)$ curves for the face-centered structure. From the $n(E)$ curves interpretations of various properties of metallic iron can be given.

[1] M. Chodorow and M. F. Manning, Phys. Rev. **52**, 731 (1937).
[2] L. Pauling, Phys. Rev. **54**, 899 (1938).

6. Thermal Expansion, Compressibility, and Electronic Polarizability of Ionic Crystals. KASIMIR FAJANS, *University of Michigan.*—Deviations from additivity of the Lorentz-Lorenz refraction and other properties of ionic substances have demonstrated[1] the tightening (decrease of refraction, polarizability, size) of electronic shells of anions in the field of cations and loosening (increase of refraction, etc.) of the shells of cations in the field of anions. The expansion coefficients of alkali halides increase, contrary to the expectations of the electrostatic lattice theory of rigid ions, from lithium to rubidium salts.[2] This can be explained if one takes into account that the increase of interionic distance with temperature causes a diminution of the tightening of the anion, i.e., an increase of its size. Since the tightening effect is stronger in the cesium chloride than in the sodium chloride structure, one can also understand why the expansion coefficients of cesium halides are larger than those of other alkali halides. The compressibility of analogous ionic crystals increases parallel to their electronic polarizability.[3] There is, however, a marked deviation from proportionality which shows that the tightening of the electronic shells due to interionic forces diminishes the compressibility. In accord with this, the compressibility is smaller for the cesium chloride than for the sodium chloride structure.

[1] K. Fajans and G. Joos, Zeits. f. Physik **23**, 1 (1924). K. Fajans, J. Chem. Phys. **9**, 281, 378 (1941).
[2] K. Fajans and H. G. Grimm, Zeits. f. Physik **2**, 308 (1920).
[3] W. A. Wooster, *Text-Book on Crystal Physics* (Cambridge, 1938).

7. On the Proof of the Maxwell-Boltzmann Distribution Law. MING-CHEN WANG, *University of Michigan.*—Part of the purpose of the H theorem of Boltzmann is to prove that the Maxwell-Boltzmann distribution law is the *only* stationary solution of the Boltzmann equation. Recently Halpern and Doermann[1] have tried to prove the same fact without introducing the H function. In this proof they made use of the principle of microscopic reversibility, which in the classical theory is only valid for spherical molecules. It will be shown that this restriction is not necessary. By making use of Boltzmann's concept of cycles of critical constellations, the proof can be simplified and extended to the general case of non-spherical molecules.

[1] Halpern and Doermann, Phys. Rev. **55**, 1077 (1939).

8. Finite Self-Energies in Radiation Theory. ALFRED LANDÉ AND L. H. THOMAS, *Ohio State University.*—The Maxwell-Yukawa field theory of the point electron[1] can be derived from a Lagrangian function, according to F. Bopp, with linear field equations for the Maxwell field D, H and the Mie field E, B. Although the energy density is not positive definite there is no conflict with general principles in this unitary theory since force and work along the path of the electron vanish identically. So there is no accumulation of energy on the electron, even if the latter vibrates with frequency $\nu>c/r_0$ (r_0=electronic radius) in spite of negative energy carried by the Yukawa waves. Moreover one can devise a scheme of transitions with positive probabilities so that the energy of the pure radiation field becomes positive, and yet correspondence with the classical Maxwell-Yukawa emission process is maintained. This scheme of transitions leads to a positive Yukawa radiation density for $\nu>c/r_0$ in addition to Planck's density of the Maxwell radiation.

[1] Developed in Phys. Rev. **60**, 514 (1941).

9. The Self-Energy of the Electron. L. H. THOMAS AND ALFRED LANDÉ, *Ohio State University.*—The theory of the interaction of electrons with the electromagnetic field may be modified by introducing an additional field of Yukawa type carrying negative energy.[1] The electrons may be supposed to satisfy Dirac's equation, initially for zero rest mass; and the fields may be supposed quantized, with longitudinal as well as with transverse waves. If a positron-electron theory is built up by second quantization, the longitudinal waves may be separated, leaving a rest mass, finite by cancellation of infinite terms between the electromagnetic and Yukawa quanta. Second-order perturbation theory (following Weisskopf) then gives zero contribution to the self-energy and momentum of the electron from the transverse waves.

[1] See Alfred Landé and L. H. Thomas, "Finite self-energies in radiation theory," preceding abstract.

FRIDAY MORNING AT 10:00 O'CLOCK

Rackham Memorial (Detroit)—Room 7

Session B

10. The Internal Temperature-Density Distribution of Sirius A. G. BLANCH AND A. N. LOWAN, *New York City*, R. E. MARSHAK, *University of Rochester* AND H. A. BETHE, *Cornell University*.—Following the procedure adopted for the sun[1] the Mathematical Tables Project, W. P. A., New York City, has integrated the star equations for Sirius A, another well-known star of the main sequence. Expressed in solar units, the mass, luminosity, radius of Sirius A are 2.34, 38.9, 1.78, respectively. The point-convective model is used as before, but Morse's[2] improved tables of the opacity coefficient replaces Strömgren's. Account is taken of the scattering opacity which becomes as much as 17 percent of the absorption opacity at the boundary of the convective core. A hydrogen content of 35 percent by weight gives fairly close fitting of the radiative envelope to the convective core, and leads to a central temperature of $29.5 \cdot 10^6$ degrees C and a central density of 37 g/cm^3. In agreement with the solar calculation, the hydrogen content does not differ from the value found with the Eddington standard model whereas the central temperature and density are considerably higher than the corresponding Eddington values. This agreement between the calculations for the sun and Sirius A is especially striking since Morse's values of the opacity are uniformly lower than Strömgren's—sometimes as much as 50 percent.

[1] Blanch, Lowan, Marshak and Bethe, Astrophys. J. **94**, 37 (1941).
[2] P. M. Morse, Astrophys. J. **92**, 27 (1940).

11. The Theory of Hydrogen Three. H. FESHBACH, *Massachusetts Institute of Technology*.—The effect of including tensor forces in the theory of H^3 has been considered. As is known, beside the $^2S_{\frac{1}{2}}$ state, the ground state also contains $^4D_{\frac{1}{2}}$, $^2P_{\frac{1}{2}}$, $^4P_{\frac{1}{2}}$ terms. There are two S states and three D states. Representations of all these have been found in Eulerian coordinates.[1] With a technique similar to Rarita and Schwinger,[2] representations have now been found in terms of operators acting on the most important $^2S_{\frac{1}{2}}$ state. The problem has been reduced to that of three coordinates in the plane of the three particles by integrating over the Eulerian angles, making use of these representations. This has been done for both exchange and non-exchange forces. The most important states turn out to be the S and D states which are anti-symmetric with respect to the exchange of two like particles, as far as their dependence on both spin and Eulerian angle is concerned. This work opens the way for an application of the James-Coolidge method to the problem.

[1] G. Breit, Phys. Rev. **35**, 569 (1930).
[2] W. Rarita and J. Schwinger, Phys. Rev. **59**, 436 (1941).

12. The Application of the W.K.B. Approximation to the Radial Dirac Equations for the Hydrogen Atom. G. E. UHLENBECK AND R. J. BESSEY, *University of Michigan*.—Following the method of Pauli, we have applied the W.K.B. approximation to the radial Dirac equations for the hydrogen atom. For the discrete spectrum this leads exactly to the Sommerfeld fine structure formula. In contrast to the unrelativistic case, the whole integer total quantum numbers and the behavior of the wave functions near the origin are given automatically right. For the continuous spectrum, the W.K.B. solutions yield, besides the correct behavior at the origin, the correct phases for $r \to \infty$.

13. On the Theory of the Internal Conversion of Gamma-Radiation. R. J. BESSEY, *University of Michigan*.—One easily derives from the Dirac equations an expression for the internal conversion coefficient of gamma-radiation in terms of a number of radial integrals. This can be done for both the K and L shells, and for arbitrary order of either electric or magnetic multipole radiation. By approximating the radial integrals one can obtain expressions in closed form, most of which have been derived in the literature by independent methods. A comparison of the numerical results for the K and L conversion coefficients and their ratio, which are given by these approximations, will be presented for the case of indium ($Z=49$, gamma-ray energy $=336$ kv). This shows that in this region, especially for the conversion coefficients themselves, more exact calculations are needed.

14. Radioactive Isotopes of Praeseodymium. J. W. DEWIRE, M. L. POOL AND J. D. KURBATOV, *Ohio State University*.—The 3.5-minute and 19-hour periods previously obtained by neutron bombardment of praeseodymium and assigned to Pr^{140} and Pr^{142}, respectively,[1,2] have been further studied. The 19-hour period has been formed by the action of alpha-particles on lanthanum, protons on cerium, and deuterons on praeseodymium. From the deuteron bombardment, a half-life of 19.3 ± 0.1 hours was obtained from observations extending over 16 half-lives. Determinations of the half-life from the other bombardments were in good agreement with this value. When studied with a magnetic spectrometer of the 180° focusing type, the Pr^{142} electron spectrum was found to be simple and had an endpoint of 2.14 ± 0.02 Mev. This is in fair agreement with the 2-Mev endpoint recently reported by Wu and Segrè at the Stanford meeting. A weak gamma-ray of about 1.9 Mev was found to be associated with this period. The ratio of the number of beta-rays to gamma-rays emitted was about 25. Praeseodymium bombarded with fast neutrons gave a 3.4 ± 0.1-minute positron period. The beta-ray spectrum from cloud chamber measurements will be shown.

[1] M. L. Pool and L. L. Quill, Phys. Rev. **53**, 437 (1938).
[2] J. K. Marsh and S. Sugden, Nature **136**, 102 (1935).

15. A Voltage Stabilizer for a D.C. Generator. W. M. SCHWARZ, *The Ohio State University.*—A very simple voltage stabilizer has been developed for use on the generator supplying the magnetic field of the Ohio State University cyclotron. It consists essentially of a power tube used as a variable shunt resistor across the generator field coils. The current in this power tube is determined by the generator output voltage, the variations of which are amplified by a direct coupled amplifier. Thus the control unit is of comparatively low power, since it is required to handle a current that is only a small fraction of the size of the total generator field current. The control obtained has been found to be quite adequate, and is of the order of one part in 2000. Except for a short warming up period, no difficulty with drift has been observed. Probably because of exceedingly stable thermal conditions in the magnet coils of the cyclotron, auxiliary current stabilization has not been found necessary.

16. A.C. Resonant Pendulum Without Iron. DAVID K. WEIMER AND HAROLD P. KNAUSS, *Ohio State University.*—An iron pendulum bob has its motion maintained if it swings toward and away from a solenoid which is part of a circuit tuned to resonance at power line frequency, the tuning being adjusted when the bob is away from the solenoid. That the maintenance of this motion does not depend on non-linear magnetic properties of iron is shown by substituting for the bob a second coil suspended coaxially with the first so that it can swing toward or away from it. The two coils are connected in series so that they attract each other, and in series with them is connected a condenser chosen to produce resonance at power-line frequency with the coils separated. The maintenance of motion is ascribed to the time lag in reaching the steady-state current corresponding to the instantaneous self-inductance at any phase of the motion. Thus the current and the attractive force are larger[1] when the coils approach than when they recede.

[1] Weimer, Phys. Rev. **60**, 65A (1941).

17. Solar Influence on Cosmic-Ray Intensity. JAMES W. BROXON, *University of Colorado.*—As reported,[1] an inverse relation between cosmic-ray intensity and international magnetic character was established by Chree's method. Similar procedure has been followed, with total sunspot area replacing magnetic character, selected days still being determined by cosmic-ray intensity. In general agreement with Graziadei and Kolhörster, an essentially inverse relation was found. For instance, a negative sunspot pulse was associated with the cosmic-ray positive primary pulse. The sunspot pulse peaks preceded the cosmic-ray primary peaks by three or four days, however. It is noted that a serious objection by Forbush to Vallarta and Godart's[2] explanation of 27-day cosmic-ray fluctuations in terms of direct influence of heliomagnetism would be removed if sunspot magnetic moments were sufficiently great. Simple estimates of magnitudes in conjunction with their computations indicate these moments are somewhat too small. The phase lead of sunspot relative to cosmic-ray pulses might be associated with the supposed solar emission of charged particles contributing to terrestrial ring currents.

[1] J. W. Broxon, Phys. Rev. **59**, 678 (1941).
[2] M. S. Vallarta and O. Godart, Rev. Mod. Phys. **11**, 180 (1939).

18. A New Cosmic-Ray Geomagnetic Relation. FOSTER EVANS, *University of Colorado.*—Previously it has been shown that if the primary cosmic radiation consists of charged particles predominantly of one sign, there is set up in the vicinity of the earth a radial current caused by the motion of slow interstellar electrons. By including the effect of the earth's magnetic field it is found that in addition to being acted upon by a radial field the interstellar electrons will move under the influence of equivalent electric fields at right angles to the radial direction in planes parallel to the plane of the magnetic equator. There results a continuous series of spherical shells of current, concentric with the earth, of current density proportional to the cosine of the latitude. If cosmic rays consist only of positively charged particles these current shells produce a magnetic field which opposes the earth's field. Hence, if cosmic-ray intensity is changed by anything other than terrestrial magnetic disturbance, this change will *produce* a magnetic disturbance at the earth's surface. It is shown that the ratio $(\Delta I/I)/(\Delta H/H)$ for this type of simultaneous change in cosmic-ray intensity and horizontal component of the earth's field is negative and of the same order of magnitude as observed experimentally.

FRIDAY AFTERNOON AT 1:45 O'CLOCK

Rackham Memorial (Detroit)—Small Lecture Room

SYMPOSIUM ON VARIOUS TOPICS OF APPLIED PHYSICS

I. Ceramic Insulators for Spark Plugs. FRANK RIDDLE, *Ceramic Division, Champion Spark Plug Co., Detroit.*

II. The Fatigue Characteristics of Rubber. F. F. YOST, *U. S. Rubber Co., Detroit.*

III. Static Electric Effects on Rubber Tired Vehicles. NIEL HANDEL, *U. S. Rubber Co., Detroit.*

IV. Some Applications of X-Ray Inspection to Defense Problems. DON M. MCCUTCHEON, *Metallurgical Engineer, Ford Motor Co., Dearborn.*

Saturday Morning at 10:00 o'clock

Rackham Building (Ann Arbor)—Amphitheatre

Session C

19. The Mercury Arc Cathode. Charles G. Smith, *Raytheon Mfg. Co., Newton, Mass.*—Conduction electrons in the liquid at the arc spot are considered to be selectively heated to about 4000°K by electronic bombardment from the vapor while the atomic structure is at about 150°C. Thermionic emission yields the arc current plus the return current from the vapor. Observations upon velocity of an arc spot pushed around a circular mercury track by a radial magnetic field show that for fields below approximately 5000 gauss, velocity is proportional to field, is in a direction opposite to the ponderomotive force, and has a negative temperature coefficient. The phenomena are interpreted as due to the Righi-Leduc effect operative in the thin layer of hot conduction electrons of the liquid. The velocity was calculated and the vertical thermal gradient deduced treating the Righi-Leduc effect as a thermomotive force. Arcs were extinguished by current pulses of 10^{-7} sec. superposed upon and in the same direction as the arc current. From these observations the energy content of the excited layer of electrons was evaluated, and therefrom the thermal gradient found. The independent estimates reveal it to be about 4×10^{8} degrees per cm. The Thomson heat counteracts losses along this gradient.

20. Pressures and Temperatures in High Pressure Mercury Lamps. Carl Kenty, *Lamp Development Laboratory, General Electric Company.*—Operating pressures in the H-type mercury lamps have been measured under a variety of conditions with quartz membrane manometers.[1] If L is the input to the lamps in watts per centimeter of arc length, m is the weight of Hg per centimeter in milligrams, and d is the diameter in millimeters, the observed pressure P in atmospheres can be represented approximately by the formula $P\leqq95(m/d^2)(L^{\frac{1}{2}}/d^{0.1}m^{0.1})$. The average temperature, T_a, of the vapor being proportional to P and inversely to m/d^2 can be represented by $T_a \leqq1800(L^{\frac{1}{2}}/d^{0.1}m^{0.1})$. Knowing the radial temperature distribution of a single lamp,[2] the values of T_a for other lamps, permits the approximation of their radial temperature distribution, and hence, also of their light and current distributions.

[1] Carl Kenty, Rev. Sci. Inst. **11**, 377 (1941).
[2] Carl Kenty and W. J. Karash, Phys. Rev. **60**, 66A (1941).

21. Self-Broadening and Foreign Gas Broadening in the Infra-Red Absorption Spectrum of HCN. H. M. Foley, *University of Michigan.*—The shapes of twenty lines in the 14μ absorption band of HCN have been examined with high resolution at a series of pressures up to 58 cm Hg. With 2-cm pressure of HCN the lines have also been measured with pressures of HCl present as a foreign gas perturber. In both cases the perturbing interaction is between polar molecules of known dipole moments, and thus form an especially favorable case for comparison of the observed absorption coefficient with the values given by the theory of pressure broadening. The observed intensity of transmission through the gas, $I(\nu)$, is related to the absorption coefficient, $\alpha(\nu)$, by

$$I(\nu)=\int_{-\infty}^{+\infty}d\nu'\rho(\nu-\nu')e^{-\alpha(\nu')l},$$

where l is the path length in appropriate units, and $\rho(\nu-\nu')$ is a function giving the spreading effect of the slit width. By numerical solution of this integral equation the absorption coefficient was obtained as a function of the frequency. The shapes of the lines and the shifts are compared with the theoretical results derived by Dr. D. M. Dennison and the author.

22. A Comparison of Certain Infra-Red Bands in C_2H_6, C_2D_6 and C_2H_5D. L. R. Posey and E. F. Barker, *University of Michigan.*—The low frequency perpendicular fundamental in C_2H_6 which occurs at 821 cm^{-1} consists of a sequence of Q branches spaced approximately 2.6 cm^{-1} apart. Except for slight variations due to proton spin the intensities decrease regularly in either direction from the strongest line at 822 cm^{-1}. The corresponding band in C_2D_6 is found near 595 cm^{-1} with a spacing of about 1 cm^{-1} between lines. In C_2H_5D, due to the departure from axial symmetry, the degeneracy is removed and the band pattern is very different. A strong central maximum appears at about 804 cm^{-1} with a set of Q branches on either side having rather low intensities near the center. A second perpendicular band in C_2H_6 occurs at 1463 cm^{-1}. The analogue in C_2D_6 is found at about 1065 cm^{-1}, with a more intense parallel band superposed upon it. The latter has a remarkably broad central maximum extending from 1060 to 1078 cm^{-1}. In C_2H_5D the corresponding perpendicular band is split into two rather widely separated components, of which the more intense lies near 1450 cm^{-1}. The less intense component appears at approximately 1300 cm^{-1}, and it also is partially obscured by a parallel band whose strong Q branch is observed at 1301 cm^{-1}.

23. Fluorescence and Absorption Spectra of Hydrogenated Chlorophyll *a*. H. V. Knorr and V. M. Albers, *Antioch College.*—A solution prepared by dissolving 13.8 mg of chlorophyll *a* in 60 cc of ether, with an additional 100 mg of platinic oxide, was hydrogenated under an average pressure of 48 lbs./in.^{2} The hydrogenation extended over a twenty-four hour period. The fluorescence spectrum of the hydrogenated chlorophyll *a* in ether and under an atmosphere of hydrogen was photographed by a method previously described.[1] The positions and relative intensities of the principal bands have been measured. There are three

principal bands located at 687, 662, and 628 mμ. The band at 628 mμ vanishes after three hours of irradiation when an additional band located at 620 mμ appears and gradually increases in intensity during the remainder of the twenty-five hours of irradiation. The 687-mμ band decreases in intensity and vanishes after ten hours of irradiation when a new band appears at 690 mμ. During the remainder of the irradiation period the intensity of the long wave-length bands decrease. Absorption curves were obtained for the original hydrogenated chlorophyll *a*, and for the final photodecomposed product.

[1] H. V. Knorr and V. M. Albers, Cold Spring Harbor Symposia on Quantitative Biology 3, 98–107 (1935).

24. The Problem of Determining a Standard for Chlorophyll Preparations. V. M. ALBERS AND H. V. KNORR, *Antioch College.*—In order to maintain proper controls in experiments using chlorophyll in medicine and other applications, it is desirable to have some convenient means of determining the concentration of the chlorophyll components in a given preparation and also of determining whether the chlorophylls present in two different preparations are actually the same. Absorption coefficient data published by different observers show wide divergence, but the methods of preparation used by these observers have also been different. Few of these observations have been accompanied by any chemical analyses and only one has been accompanied by a complete chemical analysis. A large number of chlorophyll preparations have been made in our laboratory by using different methods of preparation of the pure components. The results of the studies on these preparations indicate that samples on which absorption coefficient measurements are to be made should be subjected to careful chemical analyses to determine the percentage composition of carbon, hydrogen, nitrogen, and magnesium and also to be certain that part of the magnesium has not been replaced by another metal.

25. Valence and Central Forces in the Water Vapor Molecule. ROBERT R. NEWTON AND W. H. SHAFFER, *Ohio State University.*—Appropriate generalized coordinates have been selected for describing the vibrations of bent symmetrical XY_2 molecules for valence and central forces. In terms of these coordinates the most general forms of the quadratic and cubic parts of the potential energy function have been set up and relations have been obtained giving the force constants in these expressions in terms of those occurring in the corresponding normal coordinate expressions. These relations have applied to the data obtained by Darling and Dennison[1] on the water vapor molecule and the values of the force constants have been computed for both valence and central force type functions. The results indicate that the usual valence force approximation is better in the case of H_2O than the central force approximation as regards both the quadratic and the cubic terms in the potential energy function. The results also suggest a possible type of approximation which could be made to reduce the number of constants occurring in the cubic part of the potential function of a polyatomic molecule.

[1] B. T. Darling and D. M. Dennison, Phys. Rev. 57, 128 (1940).

26. Bond Energies in COOH and COHN Dimers, Indicated by Ultraviolet Absorption Bands. GLADYS A. ANSLOW, *Smith College.*—The interpretation of ultraviolet absorption bands in organic molecules follows from assumption of dimer structure for some of the carboxylic and $-COHN-$ molecules with the consequence that dissociation is affected by the rupture of two dimer bonds in a single photon hit. Resulting spectroscopic values of bond energies agree with thermochemical and emission band values for dissociation. Thus, the 230–200-mμ absorption by aliphatic amino acids[1] results from breaking an $O-H$ bond and an $O\cdots H$ bridge. In COHN dimers the two bands near 280 mμ[2] may result from a 2 $C-N$ and a $C-N$ and $C-C$ combination, the energies indicating stretching of the bonds. The $C-C$ bond energies in the tyrosine and tryptophane rings correspond to longer bond lengths than in the $C_6H^{5'}$s of phenylalanine and COHN dimers or in aliphatic chains. Alkaline solvents decrease the $O-H\cdots O$ energy in carboxylic dimers and the $C-C$ energies in tyrosine, but not materially the $C-N$ and $C-C$ energies in tryptophane, phenylalanine and the COHN dimers. $N-H$, $C-H$, $S-H$ and $S-S$ bond energies have been identified.

[1] G. A. Anslow and M. L. Foster, J. Biol. Chem. 97, 37 (1932); G. A. Anslow, M. L. Foster, and C. Klingler, *ibid.* 103, 81 (1933).
[2] G. A. Anslow and S. C. Nassar, J. Opt. Soc. Am. 31, 118 (1941).

SUPPLEMENTARY PROGRAMME

27. Bond Energies in Some Protein Fabrics and Side Chains. GLADYS A. ANSLOW, *Smith College.**—The lower energy component of the peptide bands[1] may be caused by the rupture of two C−N bonds by a single photon. The low energy side of the other component may result from the dissociation of a C−N and a C−C bond, the other side to two C−C's. Strong absorption in all proteins studied at 242 mμ may indicate the dissociation of C−H···O groups, existing between side chains and the solvent. Both these absorption regions are shifted to lower energies in alkaline solvents. Since two of the C−N and C−C bonds are broken simultaneously, a fabric structure theory of the protein is more probable than a long chain polypeptide chain theory. The original Wrinch[2] cyclol fabric theory appears to be supported by the alkaline shift of the peptide bands, and the probable non-existence of a N−H group. If the latter exists, C−N bands should not show alkaline shifts, (compare tryptophane and COHN dimer effects[3]), and a narrow band, found at 339 mμ in COHN dimers, should appear.

* To be called for after Paper No. 26, Session C.
[1] G. A. Anslow and S. C. Nassar, J. Opt. Soc. Am. **31**, 118 (1941).
[2] D. Wrinch, Proc. Roy. Soc. **A160**, 59 (1937).
[3] Paper No. 26.

Paper to be Read by Title

28. The Performance and Calibration of a Recording Infra-Red Spectrometer. ROBERT A. OETJEN, CHAO-LAN KAO AND H. M. RANDALL, *University of Michigan.*—This infra-red spectrograph was described by Randall and Strong in 1931. The collimating mirror has a focal length of 50 cm and the faces of the 60° NaCl prism are 80 by 100 mm. The spectrum of the 10μ NH_3 band shows that those fine structure lines having separations of 3 cm^{-1} are resolved, but lines are unresolved where the separation drops to 1.8 cm^{-1}. Judged by this practical test its resolution equals that of any prism recorder so far described. Sharp symmetrical lines can be located with a reproducibility of 0.003μ at 5μ to 0.001μ at 15μ if appropriate corrections for changes in temperature of the prism are made. The bands of water vapor at 6μ, of ammonia at 10μ, and CO_2 at 15μ have been completely remeasured with a grating instrument of high precision, whose resolution is made to equal that of the prism recorder in each of the three regions. For the purpose of calibration, over 150 standard absorption lines quite uniformly distributed between 5 and 15μ are thus obtained, which leads to an accuracy of measurement by the prism recorder essentially equal to that of the grating measurement, 0.005μ at 5μ and 0.003μ at 15μ.

SATURDAY AFTERNOON AT 1:45 O'CLOCK

Rackham Building (Ann Arbor)—Amphitheatre

SYMPOSIUM ON THE INFRA-RED

I. **Precision Measurements with the Infra-Red Recording Prism Spectrometer.** H. M. RANDALL, *University of Michigan.*

II. **The Application of a Lithium Fluoride Prism in Infra-Red Spectroscopy.** NORMAN WRIGHT, *The Dow Chemical Company, Midland.*

III. **Coriolis Interaction and the Infra-Red Spectra of Certain Polyatomic Molecules.** HARALD H. NIELSEN, *Ohio State University.*

It is anticipated that one or two additional papers will be arranged.

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